

## REMARKS

### I. Status of the Claims and the Rejections

Claim 32 was rejected under 35 U.S.C. § 102 for alleged lack of novelty based on Kleen U.S. Patent No. 2,499,736 ("Kleen"). Claims 19-22, 25, and 27-32 were rejected under 35 U.S.C. § 103 for alleged obviousness based on Fischer et al. U.S. Patent No. 5,513,500 ("Fischer") in view of Plattner U.S. Patent No. 6,658,881 ("Plattner"). Applicants respectfully traverse these rejections.

Nevertheless, claims 27, 28, and 32 have been amended to further clarify the subject matter regarded as patentable. Claim 25 has been canceled, and claims 33 and 34 have been added. Applicants respectfully request reconsideration of the rejections in view of these amendments and the following remarks.

### II. Claim 32 is Novel

#### A. The Claim

Claim 32 recites a method for the discharge of heat from a heat source located in the interior of an aircraft to a heat sink, the aircraft including a closed piping system having "a heat intake section thermally coupled to the heat source and a heat output section thermally coupled to the heat sink." The heat sink includes a section of an external wall of an aircraft. The method includes "causing, via at least one heat exchanger which operatively couples the piping system to the heat source, heat transfer in the heat intake section; and controlling, via a ventilator, the heat transfer between the at least one heat exchanger and the heat source" (emphasis added). Claim 32 has been amended to further recite "controlling, via a regulator valve disposed between the heat intake section and the heat output section, the quantity of heat conveyance medium flowing to and from the at least one heat exchanger."

### B. The Deficiencies of the Cited Prior Art

Kleen is directed to an aircraft refrigeration device for a cargo space of an aircraft. As shown in FIG. 6, the refrigeration system includes a hermetically sealed tube containing a vaporizable refrigerating medium. The hermetically sealed tube extends from a condensing chamber (11) within an air duct (31) of the aircraft and a vaporizing chamber (12) within the cargo space (B), the chambers (11, 12) connected by an intermediate connecting section (13). The condensing and vaporizing chambers (11, 12) have respective fins (14, 17) along their outer surfaces to assist in heat transfer to and from the refrigerating medium in the tube. The air duct (31) directs a flow of ambient cooling air past a duct inlet with shutters (32) and through a sequence of louvres (36) that direct the cooling air flow onto the fins (14) of the condensing chamber (11). The refrigerating medium absorbs heat in the vaporizing chamber (12) from the cargo hold (B) and turns into a gas which rises into the condensing chamber (11), where the refrigerating medium expels heat to the cooling air flow and in the process condenses back to a liquid. This refrigerating medium liquid then travels back down into the vaporizing chamber (12) where the cycle repeats to continuously deliver heat from the cargo hold (B) to the ambient cooling air flow.

Claim 32 recites a regulator valve disposed between the heat intake section and the heat output section of the piping system. The regulator valve controls the flow of heat conveyance medium. In contrast, Kleen does not recite any regulator valve or any method of regulating the flow of refrigerating medium in the hermetically sealed tube. Kleen also teaches away from adding such a regulator valve to the tube, stating that "the present invention provides a simple, small lightweight refrigerating system with no moving parts for aircraft" (Col. 1, lines

43-45). For at least this reason, Kleen does not disclose every feature of claim 32, and therefore cannot anticipate claim 32.

Additionally, the Office Action states that the cooling air flow through the duct (31) represented the "ventilator" of claim 32. However, the ventilator of claim 32 controls the heat transfer between the at least one heat exchanger and the heat source. Even if the cooling air flow through the air duct (31) of Kleen were to be construed to be a "ventilator," this cooling air flow would only affect heat transfer from the condensing chamber (12) to the air. The cooling air flow is remote from the heat source, and thus cannot control the heat transfer between a heat exchanger and the heat source, as required by claim 32.

Furthermore, the Office Action indicates that because the "heat sink" of Kleen is primarily composed of the cooling air flow in the air duct (31), the "heat sink" also includes an external wall of the aircraft at the air duct (31) because the cooling air flow (31) carries heat to an exit vent and because the end of the hermetically sealed tube contacts a single support leading to the external wall of the aircraft. Applicants do not understand this assertion. For example, in the presently claimed invention, heat leaving the system into the external wall of the aircraft may later be discharged from the external wall of the aircraft to external air flow, and then from the air to the ground. However, the external air or the ground is not part of the heat sink.

Likewise, although the air flow in the air duct (31) may carry heat toward the external wall of the aircraft, that alone does not make the external wall of the aircraft part of the heat sink. If the one support for the hermetically sealed pipe were designed to transfer heat away from the condensing section (12), as the Office Action suggests, then Kleen would have disclosed at least some details of this heat transfer. However, Kleen offers no explanation beyond stating that the cooling air flow is the heat sink. Thus, the rejection fails for this additional reason.

For at least these reasons, claim 32 is allowable over Kleen. Applicants respectfully request that the rejection of claim 32 be withdrawn.

### III. Claims 19-22 and 27-32 are Not Obvious

#### A. The Claims

Claim 19 is directed to an aircraft having a cooling device for expelling heat from a heat source located in the interior of said aircraft to a heat sink. The cooling device includes a piping system with a heat intake section thermally coupled to the heat source and a heat output section thermally coupled to the heat sink. The piping system is filled with a heat conveyance medium that changes phase from liquid to gas in the heat intake section, and from gas to liquid in the heat output section. The cooling device of claim 19 also includes a heat exchanger operatively coupling the piping system and the heat source, a ventilator controlling the transfer of heat at the heat exchanger from the heat source, and a temperature sensor at the heat source. Claim 19 further recites "a regulator valve operatively connected to the piping system, thereby to control the quantity of heat conveyance medium flowing to or from the heat exchanger; and a regulation device operatively connected to the ventilator and to the regulator valve so as to control the ventilator and the regulator valve." As discussed above, claim 32 is directed to a method including controlling the flow of heat conveyance medium using a regulator valve.

Claim 27 has been amended into an independent claim in this response, and is also directed to an aircraft having a cooling device for expelling heat from a heat source to a heat sink. The cooling device of claim 27 includes the piping system, heat exchanger, ventilator, and temperature sensor as described in claim 19. Claim 27 further recites "a cold storage unit provided between the heat source and the heat sink, the cold storage unit collecting cooled liquid

phase heat conveyance medium for use when cooling requirements are increased, such as when the aircraft is on the ground" (emphasis added).

Claims 20-22 and 28-31 depend directly or indirectly from one of independent claims 19 and 27, and include additional features of the claimed cooling system. For example, claim 31 recites that when the aircraft is in a rest condition, the heat sink is located geodetically higher than the cold storage unit, which is further located geodetically higher than the heat source.

#### B. The Deficiencies of the Cited Prior Art

Fischer is directed to a system for cooling food trolleys in the cabin of an aircraft. As shown in FIG. 2, Fischer discloses a central cooling plant (4) located underneath the cabin of an aircraft and selectively coupled to heat exchangers (9A, 9B) in the aircraft galleys via a supply conduit (5) and a return conduit (6). The heat exchangers (9A, 9B) in the galleys (3A, 3B) are coupled to the supply and return conduits (5, 6) using a plurality of connector conduits (10A, 10B, 11A, 11B) and connector adapters (35, 36) that purportedly allow quick connection and disconnection of the components cooling system (1) when cabin reorganization is necessary. The supply and return conduits (5, 6) carry a liquid cooling medium such as a water/glycol mixture, and the heat exchangers (9A, 9B) "are embodied as liquid/air heat exchangers through which the coolant flows in a primary circuit and air flows in a secondary cooling air circuit (12A, 12B)." (Col. 4, line 66 – Col. 5, line 2). The liquid cooling medium is driven by a pump (7) from the supply and return conduits (5, 6) to a heat exchanger (4') that removes heat from the liquid cooling medium.

With reference to claims 19 and 27, the Office Action acknowledges that Fischer does not teach that the heat conveyance medium undergoes phase changes at the cooling plant (4) and the heat exchangers (9A, 9B). However, the Office Action cites Plattner for the teaching

of a two-phase vaporization refrigeration device (14 of FIG. 1) on board an aircraft, and concludes that it would have been obvious to implement the Plattner refrigeration device in place of the liquid cooling system of Fischer, because of the "greater cooling capacity of harnessing the phase change of the heat conveyance medium." Applicants respectfully disagree.

Fischer teaches that the water/glycol mixture is advantageous because it allows for simple liquid/air heat exchangers to be used in each of the individual galleys (Col. 3, lines 7-13). Fischer explicitly states that the goals of the Fischer cooling system are "to provide a system for cooling food in an aircraft that makes possible the flexible arrangement or rearrangement of galleys within the aircraft cabin" and "to provide such a cooling system that reduces the total weight and space requirements and the necessary installation effort" (Col. 2, lines 5-12). Thus, Fischer clearly teaches away from the combination with Plattner that is proposed in the Office Action.

In the proposed combination, the simple liquid/air heat exchangers (9A, 9B) of Fischer would need to be replaced with all of the equipment in the Plattner system, including a receiver/dryer (18 of FIG. 1), an expansion valve (20), an evaporator (22), and a compressor (24). These additional pieces of equipment would add significant weight to the aircraft and, more importantly, would limit the reconfiguration possibilities for the cabin of the aircraft. Thus, replacing the liquid phase refrigerant of Fischer with the two-phase refrigerant of Plattner would undermine the stated benefits of Fischer. The Office Action fails to explain how the Plattner elements could be added to Fischer without adding weight and limiting the rearrangement capabilities of Fischer. It is well established that obviousness does not exist when the proposed modification of a reference substantially undermines the teachings of that reference. That is precisely the case here. For at least this reason, the rejection of claims 19 and 27 is deficient.

With reference to claim 19, the Office Action acknowledges that neither Fischer nor Plattner teaches a regulator valve operatively connected to the piping system and a regulation device. Nevertheless, the Office Action argues that the regulating unit (46) of Fischer "controls the internal refrigeration loop in the cooling plant (4)," and that the control of the refrigeration loop could be accomplished with the pump (7) acting as an analogue to the recited regulator valve. Fischer provides absolutely no indication that the regulating unit (46) controls anything other than the amount of air brought into the cooling plant (4) by the blower (15), and Plattner also does not provide any indication that a regulating unit would be coupled with a regulator valve. To sustain an obviousness rejection, the rejection must point to some teaching that supplies some objective basis for modifying the regulating unit (46) for control of the pump (7). The Office Action simply fails to find this teaching in either reference. Here, the Office Action is merely speculating about the general disclosure provided in Fischer. Therefore, even if Fischer and Plattner were combined, the resulting system would be deficient. For at least this additional reason, the rejection of claim 19 should be withdrawn.

With reference to independent claim 27, the Office Action states that Fischer discloses a "cold storage unit between the heat source and the heat sink" because the cooling plant (4) is located between the food trolleys (8A) and the skin heat exchanger (41). However, claim 27 has been amended to specifically recite that "the cold storage unit collecting cooled liquid phase heat conveyance medium for use when cooling requirements are increased." In contrast, the cooling plant (4) of Fischer does not reserve a store of condensed heat conveyance medium. Thus, Examiner cannot maintain the rejection of claim 27 by merely indicating that the "cold storage unit" is broad enough to encompass the cooling plant (4) of Fischer. Plattner fails to overcome these deficiencies of Fischer with respect to claim 27. Claim 27 is allowable over the cited references for at least this additional reason.

Applicants also observe that the corresponding patent application of the present application (EP 1,700,080) in the European Patent Office ("EPO") was allowed on September 23, 2009 with claims consistent with the scope of the current independent claims. A copy of this corresponding EPO application has been submitted with this response for review. The USPTO and the EPO have recently begun cooperating in the Patent Prosecution Highway to more quickly allow applications allowed in one patent office to be allowed with similar claims in the other patent office. The EPO did consider the Kleen and Fischer references, but nevertheless found that claims of analogous scope to be allowable over these references. Although the Patent Prosecution Highway does not apply to the current case because the USPTO prosecution started before the EPO allowance, Applicants respectfully request that the USPTO consider the EPO allowance, and also follow the spirit of the Patent Prosecution Highway during reconsideration of these rejections.

Consequently, claims 19, 27, and 32 are allowable over the cited references for at least the reasons discussed above. Each of dependent claims 20-22 and 28-31 depends on one of these independent claims, but further includes one or more additional features in combination with the features of the base claim. For substantially the same reasons set forth above with respect to independent claims 19 and 27, and further because the cited prior art, either by itself or in combination with other references, fails to teach or suggest the subject matter recited in the claims, Applicants respectfully submit that each of these claims is patentable. Applicants respectfully request that the rejection of claims 19-22 and 27-32 be withdrawn, and that these claims be allowed.

#### IV. New Claims 33 and 34 are Allowable

Claims 33 and 34 depend from independent claim 32. Claim 33 further recites "storing cooled liquid phase heat conveyance medium in the cold storage unit while the aircraft

is flying." Claim 34 further recites "releasing stored liquid phase heat conveyance medium from the cold storage unit to the heat source when the aircraft has an increased cooling requirement." These claims are fully supported in the original specification at paragraph [0052].

Claims 33 and 34 recite method steps generally analogous to the function of the cold storage unit previously discussed with respect to claim 27. As noted above, Fischer and Plattner fail to provide any element that stores liquid phase refrigerant for release when cooling requirements are increased. Therefore, claims 33 and 34 are allowable over the currently cited art. Applicants respectfully request an allowance of claims 33 and 34.

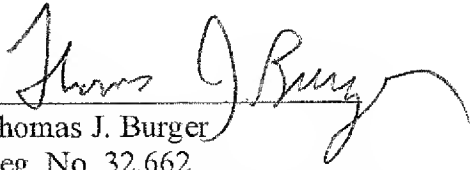
#### V. Conclusion

Based on the amendments to the claims and these remarks, Applicants respectfully asserts that all present claims are in condition for allowance, and respectfully requests an allowance without further delay.

It is believed that no fee is due for this filing. If any fee is deemed due, consider this as an authorization to charge Deposit Account 23-3000 therefore.

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(54) **COOLING SYSTEM AND METHOD FOR EXPELLING HEAT FROM A HEAT SOURCE LOCATED  
IN THE INTERIOR OF AN AIRCRAFT**

**KÜHLSYSTEM UND VERFAHREN ZUM AUSTREIBEN VON WÄRME AUS EINER SICH IN EINEM  
FLUGZEUG BEFINDENDEN WÄRMEQUELLE**

**SYSTEME DE REFROIDISSEMENT ET PROCEDE ASSOCIE PERMETTANT D'EVACUER LA  
CHALEUR D'UNE SOURCE DE CHALEUR SITUÉE A L'INTERIEUR D'UN AERONEF**

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**US-A- 5 966 951 US-A1- 2003 159 808**  
**US-B1- 6 220 338**

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Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

**EP 1 700 080 B1**

## Description

[0001] This invention relates to a cooling system for expelling heat from a heat source located in the interior of an aircraft to a heat sink or heat reducer according to the preamble part of claim 1.

[0002] In aircrafts, particularly in commercial aircrafts, there are a number of electronic devices and other functional units which give off heat during operation of the aircraft. For example, in the aircraft's on-board kitchen (galley) the food and drinks it provides must be cooled so that these remain enjoyable over a sufficiently long period of time. Moreover, within the aircraft there are a number of computer units from which large quantities of heat must also be expelled during operation so as to be able to guarantee reliable function.

[0003] In order to provide the aforementioned cooling functions, one has come up with various ideas in the past. For example, DE 38 12 739 shows a cooling system for a cooling chamber in an aircraft. With this cooling system it is proposed to convey air from a cold air chamber by means of a ventilator into a cooling chamber where a service trolley which is to be cooled is located. From the cooling chamber, partially heated air is conveyed back into the cold air chamber where this can cool down again. The cold air chamber is kept cool by the fact that it is in direct contact with a non-insulated section of the aircraft outer skin, and so during the aircraft's flight operation, in which temperatures of -50°C generally prevail on the aircraft outer skin at normal flight altitudes, the cold air chamber can be cooled effectively as a result of the thermal coupling by means of the non-insulated aircraft outer skin with the surroundings. The disadvantage of this system, however, is that the cooling chamber must be located near to the outer skin of the aircraft, and this restricts flexible interior arrangement of the aircraft. Moreover, the level of efficacy of this system is relatively low because only the perceptible heat from the air used as a heat conveyor medium can be used for heat conveyance. Finally, there is another disadvantage of this system, in that a special unit is required for the conveyance of the heat conveyance medium which causes additional parasitic heat damage.

[0004] It can generally be seen that there are considerable disadvantages with using air as a heat conveyance medium. In particular, air has relatively low specific heat conveyance performance. Moreover, a relatively large amount of space is necessary for the required piping system which can lead to additional weight and also to additional problems relating to leakage and noise. Because of the low specific heat conveyance performance, a correspondingly high conveyance performance is required which can lead to the aforementioned parasitic heat damage. Another important disadvantage of using air as a heat conveyance medium is that the waste air from the cooling of heat sources, the electronic devices for example, is usually expelled from the pressure cabin because if its heat and/or pollution, and can not be re-

circulated. Because of the balance of air in the aircraft, such quantities of waste air should, however, be limited as far as possible.

[0005] As an alternative to the use of air as a heat conveyance medium there are other solutions with which liquids are used as a heat conveyance medium. The disadvantage of these, however, is their relatively high weight. Moreover, pumps are required in order to convey the liquid heat conveyance medium which, on the one hand, leads to increased weight, and on the other hand to parasitic heat damage, and so reduce the efficacy level of the cooling unit. Finally, this type of cooling system is relatively expensive to maintain.

[0006] US 6,435,454, however, shows a system whereby the outer skin of a supersonic jet aircraft is cooled by means of cooling systems. With this system excessive heating of the outer skin of the aircraft caused by air friction is prevented so as to minimize the emission of infra-red radiation and thus reduce identification of the aircraft with infra-red detectors. Contrary to the current state of technology described above, with this system the heat from the outer skin of the aircraft is conveyed into the aircraft interior and there, for example, used to heat the fuel with the aim of efficient combustion.

[0007] US 2,499,736 describes an aircraft refrigeration system according to the preamble part of claim 1. The aircraft refrigeration system described therein uses shutters in order to duct ambient air into a cooling zone. The ambient air which is ducted into the interior of the aircraft provides a cooling airflow which contacts the heat output section in order to cool the conveyance medium. This airflow then has to be conducted back to the outside of the airplane. The requirement of conducting ambient air from outside of the aircraft into the interior and back to the outside for cooling purposes requires substantial structural provisions at the aircraft.

[0008] US 5,966,951 describes a refrigerator with automatic defrosting having a piping system with a heat conveyance medium.

[0009] Prior art document GB 1,526,160 describes a cooling system for an airplane having a heat pipe. The outer skin of the airplane is interrupted and the heat pipe is introduced into the resulting aperture. The heat pipe comprises a porous body extending through the aperture to the environment of the aircraft.

[0010] GB 1,595,961 describes a cooling device for electrical equipment having a electrically driven fan for circulating the air within the casing of the cooling device.

[0011] It is the aim of this invention to provide a cooling system and a method of the type indicated at the outset, which in relation to the current state of technology, allows heightened specific heat transfer performance with low technical cost.

[0012] This problem is solved by a cooling system which expels heat from a heat source located in the interior of an aircraft to a heat sink or heat reducer, having the features of claim 1.

[0013] With the cooling system in accordance with the

invention, in particular the latent heat of the heat conveyance medium can be used, i.e. the heat which at the phase transition from the liquid phase to the gaseous phase is taken in from the heat conveyance medium and at a later phase transition in the heat output section is given out from the gaseous phase back to a condensate, i.e. back to the liquid phase. In this way the specific heat transfer performance of the cooling system in accordance with the invention is considerably heightened in relation to conventional systems established by the current state of technology, for example DE 38 12 739, where air is used as a heat conveyance medium and only the perceptible heat of the same can be used for cooling.

[0014] Moreover, the cooling system in accordance with the invention has the additional advantage that it provides a closed system, whereby heat transfers take place via the walls of the piping system without there being any direct contact of the heat conveyance medium with external components. In this way, impurities of the heat conveyance medium and undesirable moisture penetration into the heat conveyance medium circuit can be prevented. In addition, in relation to systems with permanent liquid heat conveyance media, the cooling system in accordance with the invention has the advantages of lower weight and also the use both of the perceptible and the latent heat for heat conveyance. Another advantage of the invention is that there is no requirement for conveyance devices, such as for example, pumps in order to set the circulation in motion. Also by means of the closed circuit, undesirable condensation effects can be prevented which can otherwise, as for example with the system in accordance with DE 38 12 739, occur at points within the aircraft and lead to undesirable icing or even corrosion of these sections of the aircraft. These undesirable condensation effects arise with the current state of technology because, for example, air from the on-board kitchen (galley) is used for the conveyance of heat. In this way, ambient air humidity comes about, and this leads to the aforementioned undesirable condensation effects on the outer skin of the aircraft.

[0015] A further development of the invention proposes that the piping system includes a closed pipe of which one end section is the heat intake section, and of which the other end section is the heat output section, whereby the two end sections are connected to one another by the conveyance section. The closed pipe can be of any shape or form and so has a relatively high level of flexibility with regard to the use and arrangement of the devices requiring cooling in the aircraft interior. With a variation of the invention, the closed pipe is made from a flexible material and is of a flexible structure, if required with articulation, in order to create further levels of freedom for installation.

[0016] In accordance with the invention, it is also proposed that the heat source includes at least one component of an electronic device in the aircraft, of an on-board kitchen in the aircraft, an inner surface of the aircraft which requires cooling, or similar.

[0017] In order to further raise the efficacy level of the cooling system, the invention proposes that the heat transfer in the heat intake section and/or in the heat output section is realised by means of a heat exchanger which couples the heat source or the heat reducer/heat sink with the piping system. Controllable heat exchangers are preferably used, for example heat exchangers with variable air volume flow, in order to be able to operate the cooling system in accordance with the invention to meet with the different requirements of the devices to be cooled, for example dependent upon loading. Moreover, the cooling system in accordance with the invention also has a ventilator assigned to the respective heat exchanger by means of which the heat transfer between the heat exchanger and the heat source is controllable. The revolutions per minute of the ventilator is controlled here so that there is stronger or less strong air circulation around the heat source, according to the requirement, and so there is a greater or less great heat flow - dependent upon the ventilator's revolutions per minute - in the heat exchanger.

[0018] In accordance with the invention the flow of the heat conveyance medium between the heat intake section and the heat output section is controlled. For example, the flow cross-sections of the cooling system between the heat intake section and the heat output section can be adjusted dependent upon loading. For this, the invention provides a regulator valve by means of which the quantity of heat conveyance medium flowing to and from the heat exchanger is controlled.

[0019] When "controllability" or "control" is mentioned within the framework of this description, this includes, on the one hand, control in accordance with the specified models or reference lines, and on the other hand the case of regulation, i.e. control using feedback.

[0020] Different parameters can be established for the control or regulation. In particular, it is proposed in accordance with the invention, that a temperature sensor is positioned close to the heat source, whereby the cooling system can be controlled with reference to the temperature recorded by the temperature sensor. In addition, in connection with this it can be that the ventilator and/or the regulator valve is controlled based upon the temperature recorded by the temperature sensor. With regard to the aforementioned regulation, a further development of the invention proposes that a regulation system is provided which controls the ventilator and/or the regulator valve in accordance with the temperature recorded by the temperature sensor.

[0021] A further development of the invention proposes that a cold storage unit is provided between the heat source and the heat sink. By using cold storage units, sufficient cooling can be guaranteed when, for example, the aircraft is on the ground and because of the high external temperature it is not possible to provide cooling via the outer skin of the aircraft.

[0022] As an alternative to the arrangement of the cold storage unit between the heating source and the heat

reducer, it is also proposed in accordance with the invention for the cold storage unit to be positioned directly next to or even within the heat source. This makes it possible to make direct use of the cold stored in the cold storage unit in the section of the heat source, without the necessity of heat conveyor medium flow.

[0023] With preferred embodiments it is proposed that the piping system forms a closed circuit which connects the heat source and the heat reducer/heat sink to one another by means of a feed line and a discharge line. In this connection, one also talks about the so-called loop heat pipes. This type of system makes use of a drop in pressure resulting from the phase transition of the heat conveyance medium and the force of gravity. In the heating source section, the heat conveyance medium evaporates and moves to the heater reducer which is preferably positioned at a higher level, geodetically. Here, the heat conveyance medium vapour condenses and gives out the condensation heat which is released in this way. The resulting condensate flows back to the heat source, driven by the force of gravity and/or the capillary effect in a special condensate line. By means of the phase change and the use of latent heat, the heat output conveyed for each flow mass is several times higher than with the conveyance of liquids or air without phase transfer. In addition, there is no requirement for any special conveyance equipment, for example in the form of a pump.

[0024] When using this type of closed circuit with a feed line and a discharge line between the heat source and the heat reducer/heat sink, it is also proposed in accordance with the invention that the cold storage unit in a special circuit is provided with a special piping system. It is thus possible to provide a cold storage-free piping system between the heat source and the heat reducer and an additional piping system between the heat source and the heat reducer which has a cold storage unit. In order to make better use of the force of gravity, it is also proposed in accordance with the invention, that when the aircraft is in rest position, the heat reducer/heat sink is positioned at a higher level geodetically than the cold storage unit and the heat source.

[0025] It should be pointed out that the cooling system described above can be used to the opposite effect. It is, therefore, possible to use the cooling system for the general conveyance of heat, i.e. for example to expel the heat from the aforementioned heat sources and to use this to heat individual aircraft components.

[0026] As well as the aforementioned advantages, another particular advantage of the invention is that the heat source and the heat reducer/heat sink can be uncoupled from one another, and can be connected with a higher level of variability by means of the flexibly located, sealed piping system, in particular the closed pipe. Moreover, there is no requirement for any active components such as blowers or pumps in the heat conveyance route because, as a result of the phase transition, the heating medium can more or less convey itself from the heat

source to the heat reducer - due to the given diffusion gradient and/or the force of gravity-, and following condensation in the heat reducer/heat sink section - essentially as a result of capillary effects and/or the force of gravity - flows back to the heat source. This can be supported by the fact, for example, that there is a slight incline between the heat reducer and the heat source. This makes it possible to operate the cooling system without the need for any additional energy, for example to drive pumps, and also without any additional parasitic heat damage, for example from the operational heat of a conveyance pump. In addition, because additional active components are avoided, the reliability of the system is increased and maintenance costs are reduced. Moreover, unnecessary noise emissions, for example the noises arising from the powering of active components, can be prevented.

[0027] The invention also relates to a method having the features according to claim 12.

[0028] In the following, an example of the invention is described with reference to the attached figures:

Fig. 1 shows a schematic view of a closed piping system used within the framework of this invention;

Fig. 2 shows a modified schematic view of a piping system in the form of a closed pipe used within the framework of this invention;

Fig. 3 shows a further modified version of the piping system in the form of a closed circuit with separate feed and discharge lines;

Fig. 4 shows a schematic view of an example of a cooling system;

Fig. 5 shows a cooling system in accordance with the invention, modified in relation to fig. 4, with a regulation device;

Fig. 6 shows a schematic view of a second example of a cooling system in accordance with the invention, and

Fig. 7 shows a schematic view of a third example of the cooling system in accordance with the invention.

[0029] In fig. 1 a container in the form of a piping system, for use with a cooling system in accordance with the invention, is illustrated, partly as a section, and identified in general by 10. The container contains a circular cylindrical pipe, the faces of which are closed. In the lower section of the container, a heat conveyance medium 12 is shown in the liquid phase.

[0030] The lower section 14, which will also be identified in the following as the heat input section 14, of the container 10 is in thermal contact with a heat source,

whereby - as shown by the arrow 16 - heat from the heat source passes into the heat input section 14 of the container 12. This heat in accordance with the arrows 16 causes the heat conveyance medium 12 to boil, as shown by the bubbles 18 in the heat conveyance medium 12, and it finally evaporates, as shown by the vertical, upwards pointing arrows 20 in fig. 1.

**[0031]** The heat conveyance medium vapour rises to the top of the container 10 via a conveyance section 21 and passes from the heat intake section 14 to a heat output section 22, whereby it crosses a transition section 24 between the heat intake section 14 and the heat output section 22.

**[0032]** In the heat output section 22, the container 10 is in thermal contact with a heat reducer, by means of which, in accordance with the arrows 26, heat is expelled from the heat conveyance medium. This means that the heat conveyance medium is precipitated on the walls of the container 10 in accordance with the arrows 28, and condenses here. The condensate then flows vertically downwards in the container 10, in accordance with the arrows 30 pointing vertically downwards in fig. 1, as a result of the force of gravity, and this collects again in the liquid phase for renewed heat intake.

**[0033]** In the container 10, therefore, the intake of heat in accordance with the arrows 16 in the heat intake section and the output of heat in accordance with the arrows 26 in the heat output section independently generates a heat conveyance medium circuit with phase transition from the liquid phase in accordance with reference number 12 to the gaseous phase in accordance with reference numbers 20 and 28. In this way, both the perceptible heat of the heat conveyance medium and the latent heat, i.e. the heat stored in the heat conveyance medium during a phase transition, are used to convey heat from the heat intake section 14 to the heat output section 22. In the heat output section 22, this latent heat is released again by condensation of the heat conveyance medium vapour. Overall, effective heat conveyance is achieved with relatively little weight caused by filling the container 10.

**[0034]** Figure 2 shows a system similar to fig. 1, but whereby a capillary effect is used rather than the force of gravity. For this, a capillary structure 11a is set up within the pipe 10a, and this extends essentially in parallel to the length of the pipe 10a. On the inside of the capillary structure 11a, the heat conveyance medium evaporates in the heat intake section 14a, whereby there is a flow of vapour to the left, in accordance with the arrows 20a in fig. 2.

**[0035]** In the heat output section 22 the heat conveyor medium condenses again so that there is a return flow in accordance with the arrows 30a and 30b outside of the capillary structure along the long walls of the pipe. Fig. 2, on the other hand, shows the heat intake section 14a as an evaporation zone, and the conveyance section 21a and the heat output section 22a as a condensation zone. The liquid conveyance results from a capillary ef-

fect and pressure equalisation.

**[0036]** Figure 3 shows another variation of the piping system. In the example the piping system is in the form of a closed circuit with a feed line and a discharge line between the heat intake section 14b and the heat output section 22b. With impulsion from the given drop in pressure and the force of gravity, the evaporated heat conveyance medium in the heat source 14b is conveyed to the heat reducer in the heat output section 22b, in accordance with the arrow 20b. If the temperature is sufficiently low here, the evaporated heat conveyance medium condenses and so discharges the condensation heat which is released. The resulting condensate flows over the condensate line back to the heat intake section, driven by the force of gravity, in accordance with the arrow 30b. With the system in accordance with fig. 3 one talks of a loop heat pipe (LHP).

**[0037]** Figure 4 shows a possible application for the piping system 10a in an aircraft. In detail, the piping system 10a in fig. 4 is coupled with an outer skin 32 of a commercial aircraft by means of its heat output section 22, whereby the outer skin 32 is at least largely non-insulated in the vicinity of the heat output section 22. In its heat intake section 14, the piping system 10 is provided with a number of ribs 34 which extend the surface of the heat intake section, and so facilitate better heat transfer.

**[0038]** In addition, in fig. 4 there is a device requiring cooling 38 located on a cabin floor 36, for example a fridge for an on-board kitchen (galley), which has an internal ventilator 40. The ventilator 40 circulates air within the device requiring cooling so that a warm flow of air 42 is conveyed to the heat intake section 14 and gives out heat to this, and a cold flow of air 44 is conveyed away from the heat intake section 14 by means of the ventilator 40.

**[0039]** It is possible to cool the device requiring cooling 38 at relatively low technical cost. Because the container 10, as already described above, is in the form of a pipe and so requires only a small amount of space, the device to be cooled 38 can be positioned more or less anywhere within the aircraft without the level of cooling being effected or prejudiced to any extent by the positioning of the device requiring cooling 38. In particular it should be pointed out, as clearly shown by fig. 4, that the device requiring cooling 38 is largely uncoupled from the outer skin 32 of the aircraft acting as a heat reducer, and is only connected by means of the pipe 10.

**[0040]** Figure 5 shows an embodiment of the invention with a cooling system modified in relation to fig. 4. In order to simplify the description and to avoid repetition, the same reference numbers as used in the description for fig. 4 will be used for components of the same type or used to the same effect, but with the figure "1" placed in front.

**[0041]** The embodiment in accordance with fig. 5 is different from the cooling system of fig. 4 in that components for the regulation of the cooling system in accord-

ance with the invention are provided. In particular, there is a temperature sensor 150 in the device to be cooled which is coupled directly with a regulation device 152, and so passes the temperature values recorded onto the regulation device. In addition, the regulation device 152 is coupled with the ventilator 140 by means of a control line 154 for control of the same. Moreover, the regulator 152 is coupled by means of another control line 156 with an adjustable regulator valve or thermostat valve 158.

[0042] The system in accordance with fig. 5 works as follows. The temperature in the device to be cooled 138 is determined by means of the temperature sensor 150 and communicated to the regulator 152. If the temperature in the device to be cooled 138 is too high, the regulator 152 controls, for example, the ventilator 140 by means of the control line 154 so that the revolutions per minute of the same is increased. In this way, the circulation of the air flow 142, 144 is also increased so that a larger quantity of heat is transferred by means of the heat exchanger 134 from the device to be cooled 138 to the heat transfer medium. As an addition or as an alternative to this, the regulator 152 by means of the control line 156 controls the regulator valve 158, by means of which the flow of heat conveyance medium can be controlled. In this way it is possible to allow a larger amount of heat conveyance medium to flow through the piping system 110a, and so also to increase the amount of heat carried away from the device to be cooled 138.

[0043] In one application whereby ice can form in the heat exchanger section 134, the regulation device 152 can also be used specifically to defrost the heat exchanger 134.

[0044] Figure 6 shows another embodiment of the invention. Once again, the same reference numbers are used as previously in the descriptions for fig. 4 and 5 for components of the same type or used to the same effect, but with the figure "2" placed in front.

[0045] Figure 6 shows that the device to be cooled 238 is connected to the outer skin 232 of the aircraft by means of two circuits 260 and 262. For this, a coupling device 264 is used which helps with the thermal coupling of the two circuits 260 and 262 to the outer skin 232.

[0046] In the first circuit 260 a cold storage unit 266 is provided which has a thermally insulating wall 268. The circuit 260 is designed with a first connection line 270, 272 over which the evaporated heat conveyance medium flows from the heat exchanger 234 to the coupling device 264. In addition, the first circuit includes two reverse lines 274, 276, along which the condensed heat conveyance medium can flow back to the heat exchanger 234. Controllable regulation devices 278, 280 are provided in these reverse lines 274, 276.

[0047] The second circuit 262 includes a supply line 282 and a reverse flow line 284, whereby in the latter there is, once again, a controllable regulator valve 286. The second circuit 262 connects the coupling device 264 with the heat exchanger 288.

[0048] The system in accordance with fig. 6 functions

as follows. In order to cool the device to be cooled 238 during normal operation, ie. during the flight operation of the aircraft, the second circuit 262 is essentially used. This works as described above with reference to figs. 4 and 5, ie. there is an intake of heat in the device to be cooled 238 and this heat is conveyed away by means of the condensed heat conveyance medium by means of the line 282 to the coupling device 264. Here, the heat is discharged to the cold external skin 232, whereby the heat conveyance medium condenses and flows back to the heat exchanger 288 via the reverse flow line 284. The quantity of heat transferred by the flow of air 242 can be changed by altering the revolutions per minute of the ventilator 240 and by setting the regulator valve 286.

[0049] In addition to this system, circuit 260 is provided which includes the cold storage unit 266. The cold storage unit 266 serves to provide sufficient cold for situations in which the cooling provided by the circuit 260 is insufficient. For this, during normal operation in the circuit 260, the valve 280 remains closed, whereas the valve 278 is opened. In this way the cold storage unit 266 can be loaded, whereby the heat conveyance medium is cooled and stored in the storage unit 266 in condensed form. If there is an increased cold requirement, for example when the aircraft is on the ground and it is not possible to provide cooling by means of the outer skin 232, the regulator valve 278 can be shut and the regulator valve 280 opened so that there is a flow of heat conveyance medium through the circuit 260 and the device to be cooled 238 can be by using the additional flow of air 242' generated by the ventilator by means of the condensed heat conveyor medium stored in the cold storage unit 266.

[0050] It should be noted that with the embodiment in accordance with figure 6, the average temperature level of the cold storage unit 266 must lie between that of the device to be cooled 238 and that of the heat reducer 264.

[0051] It is also pointed out that in the application according to fig. 6, the heat reducer, ie. the coupling device 264 should be geodetically higher than the cold storage unit 266, and this in turn should be geodetically higher than the heat source, ie. the heat exchanger 234. This facilitates a reverse flow of liquid brought about by the force of gravity, and improves the overall heat conveyance performance.

[0052] It should finally be noted that the heat exchangers 234 and 238 in the device to be cooled can have parallel or serial flow in relation, to the air flow 242 or 242'.

[0053] Figure 7 shows a simplified embodiment in relation to fig. 6. Once again, the same reference numbers are used for components of the same type or used to the same effect as in the description for fig. 6, but with the figure "3" placed in front.

[0054] The embodiment in accordance with fig. 7 differs from the form in accordance with fig. 6 in that the cold storage unit 366 is positioned inside the device to be cooled 338. This means that, during operation, the cold conveyance medium stored inside the cold storage unit 366 can discharge its cold directly to the device to

be cooled 338 without a flow of heat conveyance medium being necessary. This can happen, for example, by means of natural convection or with a special ventilator. Alternatively, it is also possible for a flow of air via the ventilator 340 to be conveyed either to the cold storage unit 366 or to the heat exchanger 388, dependent upon the operation in question. For example, during normal operation, when the aircraft is in the air and the outer skin 332 can be used as a heat reducer, the device to be cooled 338 is cooled by the circuit 362, whereas when the aircraft is on the ground and the outer skin 332 can not serve as a heat reducer because of the high external temperatures, circuit 360 is used for cooling.

#### Claims

1. Aircraft having a cooling device including a heat pipe for expelling heat from a heat source (38; 138; 238; 338) located in the interior of said aircraft to a heat sink (32; 132; 232; 332), with a piping system (10; 110) sealed against the surrounding atmosphere, which is thermally coupled to a heat intake section (14; 114) with the heat source (38; 138; 238; 338) and to a heat output section (22) with the heat sink (32; 132; 232; 332); and which preferably has an essentially adiabatic conveyance section (21, 21a), whereby the piping system (10) is filled with a heat conveyance medium (12) which, when it takes in heat from the heat source (38; 138; 238; 338) in the heat intake section (14; 114) undergoes a transition from the liquid phase to the gaseous phase, then flows into the heat output section (22; 122) and here, when discharging heat to the heat sink (32; 132; 232; 332), condenses once again and flows back into the heat intake section (14; 114), wherein said heat sink (32; 132; 232; 332) includes a section of an external wall forming the outer skin of the aircraft, and wherein the heat transfer in the heat intake section (14; 114) and/or in the heat output section (22; 122) takes place by means of a heat exchanger (34; 134; 234; 334) which couples the heat source (38; 138; 238; 338) and the heat sink (32; 132; 232; 332) with the piping system (10), **characterized in that** a ventilator (40; 140; 240; 340) is assigned to the respective heat exchanger (34; 134; 234; 334), by means of which the transfer of heat between the heat exchanger (34; 134; 234; 334) and the heat source (38; 138; 238; 338) is controlled, wherein the flow of heat conveyance medium (20) is controlled between the heat intake section (14; 114) and the heat output section (22; 122; 222; 322), and wherein a regulator valve (158; 278; 280; 286; 378; 386) is assigned to the cooling system, by means of which the quantity of heat conveyance medium flowing to and/or from the heat exchanger (34; 134; 234; 334) is controlled.
2. Aircraft in accordance with claim 1, whereby the piping system (10, 10a) includes a closed pipe, of which one end section is the heat intake section (14, 14a) and of which the other end section is the heat output section (22, 22a), whereby both end sections are connected to one another via the conveyance section (21, 21a).
3. Aircraft in accordance with claim 1 or 2, whereby the heat source (38; 138; 238; 338) includes at least one component of an electronic device in the aircraft, an on-board kitchen in the aircraft, a surface requiring cooling in the aircraft, or similar.
4. Aircraft in accordance with any of the previous claims, whereby a temperature sensor (150) is located in the section of the heat source (138; 238; 338), whereby the cooling system is controlled with reference to the temperature recorded by the temperature sensor (150).
5. Aircraft in accordance with claim 4, whereby the ventilator (40; 140; 240; 340) and/or the regulator valve (158; 278; 280; 286; 378; 386) is controlled in accordance with the temperature recorded by the temperature sensor (150).
6. Aircraft in accordance with claim 5, whereby a regulation device (152) is provided, which controls the ventilator and/or the regulator valve in accordance with the temperature recorded by the temperature sensor (150).
7. Aircraft in accordance with any of the previous claims, whereby a cold storage unit (266) is provided between the heating source (238) and the heat sink.
8. Aircraft in accordance with any of the claim 1 to 6, whereby a cold storage unit (366) is provided in the section of the heat source (338).
9. Aircraft in accordance with any of the previous claims, whereby the piping system (260, 262; 360, 362) forms a closed circuit which connects the heat source (238; 338) and the heat sink (264; 364) by means of a feed line and a discharge line respectively.
10. Aircraft in accordance with claim 7 or 9, whereby the cold storage unit (266; 366) is located in a special circuit with a special piping system (260; 362).

11. Aircraft in accordance with any of the previous claims,  
whereby when the aircraft is in rest condition, the heat sink (264) is located geodetically higher than the cold storage unit (266) and the heat source (238).

12. Method for the discharge of heat from a heat source (38; 138; 238; 338) located in the interior of an aircraft to a heat sink (32; 132; 232; 332), whereby a piping system (10; 110) sealed against the surrounding atmosphere, which is thermally coupled to a heat intake section (14; 114) with the heat source (38; 138; 238; 338) and is thermally coupled to a heat output section (22) with the heat sink (32; 132; 232; 332), and which preferably has an essentially adiabatic transport section (21, 21a), is filled with a heat conveyance medium (12) which, when heat is taken from the heat source (38; 138; 238; 338) in the heat intake section (14; 114) undergoes a transition from the liquid phase to the gaseous phase, then flows into the heat output section (22) and here, when heat is discharged to the heat sink (32; 132; 232; 332) condenses again and flows back into the heat intake section (14; 114),  
wherein said heat sink (32; 132; 232; 332) includes a section of an external wall of the aircraft, and wherein the heat is transferred in the heat intake section (14; 114) and/or in the heat output section (22; 122) by means of a heat exchanger (34; 134; 234; 334) which couples the heat source (38; 138; 238; 338) and the heat sink (32; 132; 232; 332) with the piping system (10),  
characterized in that a ventilator (40; 140; 240; 340) assigned to the respective heat exchanger (34; 134; 234; 334) is used for controlling the heat transfer between the heat exchanger (34; 134; 234; 334) and the heat source (38; 138; 238; 338), wherein the flow of heat conveyance medium (20) is controlled between the heat intake section (14; 114) and the heat output section (22; 122; 222; 322), and wherein a regulator valve (158; 278; 280; 286; 378; 386) is assigned to the cooling system, by means of which the quantity of heat conveyance medium flowing to and/or from the heat exchanger (34; 134; 234; 334) is controlled.

reich (22) mit der Wärmesenke (32; 132; 232; 332) gekoppelt ist, und welches bevorzugt einen im Wesentlichen adiabatischen Transportabschnitt (21, 21a) aufweist, wobei das Leitungssystem (10) mit einem Wärmeträgermittel (12) gefüllt ist, das dann, wennes Wärme von der Wärmequelle (38; 138; 238; 338) in dem Wärmeaufnahmebereich (14; 114) aufnimmt, einen Übergang von der flüssigen Phase in die gasförmige Phase vollzieht, dann in den Wärmeabgabebereich (22; 122) strömt und dort beim Abgeben der Wärme an die Wärmesenke (32; 132; 232; 332) erneut kondensiert und in den Wärmeaufnahmebereich (14; 114) zurückströmt, wobei die Wärmesenke (32; 132; 232; 332) einen Abschnitt einer die Flugzeughaut bildenden Außenwand umfasst, und wobei der Wärmeübergang in dem Wärmeaufnahmebereich (14; 114) und/oder in dem Wärmeabgabebereich (22; 122) mittels eines Wärmetauschers (34; 134; 234; 334) erfolgt, der die Wärmequelle (38; 138; 238; 338) und die Wärmesenke (32; 132; 232; 332) mit dem Leitungssystem (10) koppelt, **dadurch gekennzeichnet, dass** ein Ventilator (40; 140; 240; 340) dem jeweiligen Wärmetauscher (34; 134; 234; 334) zugeordnet ist, durch den der Wärmeübergang zwischen dem Wärmetauscher (34; 134; 234; 334) und der Wärmequelle (38; 138; 238; 338) gesteuert wird, wobei der Fluss des Wärmeträgermediums (20) zwischen dem Wärmeaufnahmebereich (14; 114) und dem Wärmeabgabebereich (22; 122; 222; 322) gesteuert wird und wobei ein Regelventil (158; 278; 280; 286; 378; 386) dem Kühlsystem zugeordnet ist, durch das die Menge an Wärmeträgermedium gesteuert wird, das zu dem Wärmetauscher (34; 134; 234; 334) hin oder von diesem wegströmt.

2. Flugzeug nach Anspruch 1, wobei das Leitungssystem (10, 10a) eine geschlossene Leitung umfasst, von der ein Endbereich der Wärmeaufnahmebereich (14; 14a) ist und von der der andere Endbereich der Wärmeabgabebereich (22, 22a) ist, wobei beide Endbereiche miteinander über den Transportbereich (21, 21a) verbunden sind.

3. Flugzeug nach Anspruch 1 oder 2, wobei die Wärmequelle (38; 138; 238; 338) wenigstens eine Komponente einer elektronischen Vorrichtung in dem Flugzeug, einer Bordküche in dem Flugzeug, einer zu kühlenden inneren Fläche in dem Flugzeug oder dergleichen ist.

4. Flugzeug nach einem der vorangehenden Ansprüche, wobei ein Temperatursensor (150) in dem Abschnitt der Wärmequelle (138; 238; 338) angeordnet ist, wobei das Kühlsystem nach Maßgabe der von dem

#### Patentansprüche

1. Flugzeug mit einer Kühleinrichtung umfassend ein Wärmerohr zum Abführen von Wärme von einer im Innenraum des Flugzeugs angeordneten Wärmequelle (38; 138; 238; 338) zu einer Wärmesenke (32; 132; 232; 332), mittels eines gegenüber der umgebenden Atmosphäre abgedichteten Leitungssystems (10; 110), welches thermisch in einem Wärmeeinlassbereich (14; 114) mit der Wärmequelle (38; 138; 238; 338) und in einem Wärmeabgabebereich

- Temperatursensor (150) erfassten Temperatur gesteuert wird.
5. Flugzeug nach Anspruch 4,  
wobei der Ventilator (40; 140; 240; 340) und/oder das Regelventil (158; 278; 280; 286; 378; 386) nach Maßgabe der von dem Temperatursensor (150) erfassten Temperatur gesteuert wird. 5
  6. Flugzeug nach Anspruch 5,  
wobei eine Regelvorrichtung (152) vorgesehen ist, die den Ventilator und/oder das Regelventil nach Maßgabe der von dem Temperatursensor (150) erfassten Temperatur steuert. 10
  7. Flugzeug nach einem der vorangehenden Ansprüche,  
wobei eine Kältespeichereinheit (266) zwischen der Wärmequelle (238) und der Wärmesenke angeordnet ist. 15 20
  8. Flugzeug nach einem der Ansprüche 1 bis 6,  
wobei eine Kältespeichereinheit (366) im Bereich der Wärmequelle (338) vorgesehen ist. 25
  9. Flugzeug nach einem der vorangehenden Ansprüche,  
wobei das Leitungssystem (260, 262; 360, 362) einen geschlossenen Kreislauf bildet, der die Wärmequelle (238; 338) und die Wärmesenke (264; 364) mittels einer Zuführleitung und einer Abgabelitung verbindet. 30
  10. Flugzeug nach Anspruch 7 oder 9,  
wobei die Kältespeichereinheit (266; 366) in einem eigenen Kreislauf mit einem eigenen Leitungssystem (260; 362) angeordnet ist. 35
  11. Flugzeug nach einem der vorangehenden Ansprüche,  
wobei dann, wenn das Flugzeug sich in einer Ruhelage befindet, die Wärmesenke (264) geodätisch höher als die Kältespeichereinheit (266) und die Wärmequelle (238) angeordnet ist. 40 45
  12. Verfahren zum Abführen von Wärme von einer im Inneren eines Flugzeugs angeordneten Wärmequelle (38; 138; 238; 338) zu einer Wärmesenke (32; 132; 232; 332), wobei ein gegen die Umgebungsluft abgedichtetes Leitungssystem (10; 110), das thermisch in einem Wärmeaufnahmebereich (14; 114) mit der Wärmequelle (38; 138; 238; 338) gekoppelt ist und thermisch in einem Wärmeabgabebereich (22) mit der Wärmesenke (32; 132; 232; 332) gekoppelt ist, und das bevorzugt einen im Wesentlichen adiabatischen Transportbereich (21, 21a) aufweist, mit einem Wärmeträgermedium (12) gefüllt ist, das dann, wenn Wärme von der Wärmequelle

(38; 138; 238; 338) in dem Wärmeaufnahmebereich (14; 114) aufgenommen wird, einen Übergang von der flüssigen Phase zu der gasförmigen Phase vollzieht, dann in den Wärmeabgabebereich (22) strömt und dort, wenn Wärme an die Wärmesenke (32; 132; 232; 332) abgegeben wird, wieder kondensiert und in den Wärmeaufnahmebereich (14; 114) zurückströmt,  
wobei die Wärmesenke (32; 132; 232; 332) einen Abschnitt einer Außenwand des Flugzeugs umfasst, und wobei die Wärme in dem Wärmeaufnahmebereich (14; 114) und/oder in dem Wärmeabgabebereich (22; 122) mittels eines Wärmetauschers (34; 134; 234; 334) übertragen wird, der die Wärmequelle (38; 138; 238; 338) und die Wärmesenke (32; 132; 232; 332) mit dem Leitungssystem (10) koppelt, **dadurch gekennzeichnet, dass** ein Ventilator (40; 140; 240; 340), der dem jeweiligen Wärmetauscher (34; 134; 234; 334) zugeordnet ist, zum Steuern des Wärmeübergangs zwischen dem Wärmetauscher (34; 134; 234; 334) und der Wärmequelle (38; 138; 238; 338) eingesetzt wird,  
wobei der Strom des Wärmeträgermediums (20) zwischen dem Wärmeaufnahmebereich (14; 114) und dem Wärmeabgabebereich (22; 122; 222; 322) gesteuert wird, und wobei ein Regelventil (158; 278; 280; 286; 378; 386) dem Kühlsystem zugeordnet ist, durch das die Menge an Wärmeträgermedium gesteuert wird, das dem Wärmetauscher (34; 134; 234; 334) zuströmt und/oder von diesem wegströmt.

#### Revendications

1. Avion ayant un dispositif de refroidissement incluant un tuyau de chaleur pour expulser une chaleur provenant d'une source de chaleur située dans l'intérieur dudit avion (38; 138; 238; 338) vers un puits de chaleur (32; 132; 232; 332), avec un système de tuyauterie (10; 110) étanche à l'atmosphère environnante, qui est thermiquement couplé à une section d'admission de chaleur (14; 114) avec la source de chaleur (38; 138; 238; 338) et à une section de sortie de chaleur (22) avec le puits de chaleur (32; 132; 232; 332), et qui préférentiellement a une section de transport (21, 21a) essentiellement adiabatique, dans lequel le système de tuyauterie (10) est rempli avec un milieu de transport de chaleur (12) qui, lorsqu'il prend de la chaleur provenant de la source de chaleur (38; 138; 238; 338) dans la section d'admission de chaleur (14; 114), subit une transition de la phase liquide à la phase gazeuse, puis s'écoule à l'intérieur de la section de sortie de chaleur (22; 122) et là, lors de la décharge de la chaleur vers le puits de chaleur (32; 132; 232; 332), se condense à nouveau et reflue à l'intérieur de la section d'admission de chaleur (14; 114), dans lequel ledit puits de chaleur (32; 132; 232; 332)

- inclut une section d'une paroi externe formant la peau extérieure de l'avion, et que le transfert de chaleur dans la section d'admission de chaleur (14; 114) et/ou dans la section de sortie de chaleur (22; 122) se fait au moyen d'un échangeur de chaleur (34; 134; 234; 334) qui couple la source de chaleur (38; 138; 238; 338) et le puits de chaleur (32; 132; 232; 332) avec le système de tuyauterie (10),
- caractérisé en ce qu'un ventilateur (40; 140; 240; 340) est attribué à l'échangeur de chaleur (34; 134; 234; 334) respectif, au moyen duquel le transfert de chaleur entre l'échangeur de chaleur (34; 134; 234; 334) et la source de chaleur (38; 138; 238; 338) est commandé,**
- dans lequel le flux du milieu de transport de chaleur (20) est commandé entre la section d'admission de chaleur (14; 114) et la section de sortie de chaleur (22; 122; 222; 322), et dans lequel un robinet de régulateur (158; 278; 280; 286; 378; 386) est attribué au système de refroidissement, au moyen duquel la quantité de milieu de transport de chaleur s'écoulant vers et/ou de l'échangeur de chaleur (34; 134; 234; 334) est commandé.
2. Avion selon la revendication 1, dans lequel le système de tuyauterie (10, 10a) inclut un tuyau fermé, dont une section d'extrémité est la section d'admission de chaleur (14; 14a) et dont l'autre section d'extrémité est la section de sortie de chaleur (22; 22a), dans lequel les deux sections d'extrémité sont reliées l'une à l'autre par l'intermédiaire de la section de transport (21, 21a).
  3. Avion selon la revendication 1 ou 2, dans lequel la source de chaleur (38; 138; 238; 338) inclut au moins un composant d'un dispositif électronique dans l'avion, une cuisine de bord dans l'avion, une surface nécessitant un refroidissement dans l'avion, ou similaire.
  4. Avion selon l'une quelconque des revendications précédentes, dans lequel un capteur de température (150) est situé dans la section de la source de chaleur (138; 238; 338), dans lequel le système de refroidissement est commandé en référence à la température enregistrée par le capteur de température (150).
  5. Avion selon la revendication 4, dans lequel le ventilateur (40; 140; 240; 340) et/ou le robinet de régulateur (158; 278; 280; 286; 378; 386) est commandé en fonction de la température enregistrée par le capteur de température (150).
  6. Avion selon la revendication 5, dans lequel un dispositif de régulation (152) est prévu qui commande le ventilateur et/ou le robinet de

régulateur en fonction de la température enregistrée par le capteur de température (150).

7. Avion selon l'une quelconque des revendications précédentes, dans lequel une unité de stockage de froid (266) est prévue entre la source de chaleur (238) et le puits de chaleur.
8. Avion selon l'une quelconque des revendications 1 à 6, dans lequel une unité de stockage de froid (366) est prévue dans la section de la source de chaleur (338).
9. Avion selon l'une quelconque des revendications précédentes, dans lequel le système de tuyauterie (260; 262; 360; 362) forme un circuit fermé qui relie la source de chaleur (238; 338) et le puits de chaleur (264; 364) au moyen d'une ligne d'alimentation et d'une ligne d'évacuation respectivement.
10. Avion selon la revendication 7 ou 9, dans lequel l'unité de stockage de froid (266; 366) est située dans un circuit spécial avec un système de tuyauterie spécial (260; 362).
11. Avion selon l'une quelconque des revendications précédentes, dans lequel lorsque l'avion est à l'état de repos, le puits de chaleur (264) est situé géodésiquement plus haut que l'unité de stockage de froid (266) et la source de chaleur (238).
12. Procédé d'évacuation de chaleur provenant d'une source de chaleur (38; 138; 238; 338) située dans l'intérieur d'un avion vers un puits de chaleur (32; 132; 232; 332), dans lequel un système de tuyauterie (10; 110) étanche à l'atmosphère environnante, qui est thermiquement couplé à une section d'admission de chaleur (14; 114) avec la source de chaleur (38; 138; 238; 338) et est thermiquement couplé à une section de sortie de chaleur (22) avec le puits de chaleur (32; 132; 232; 332), et qui préférentiellement a une section de transport (21, 21a) essentiellement adiabatique, est rempli avec un milieu de transport de chaleur (12) qui, lorsque de la chaleur est prise de la source, subit une transition de la phase liquide à la phase gazeuse, puis s'écoule à l'intérieur de la section de sortie de chaleur (22) et là, lorsque de la chaleur est déchargée vers le puits de chaleur (32; 132; 232; 332), se condense à nouveau et reflue à l'intérieur de la section d'admission de chaleur (14; 114), dans lequel ledit puits de chaleur (32; 132; 232; 332) inclut une section d'une paroi externe de l'avion, et que la chaleur est transférée dans la section d'admission de chaleur (14; 114) et/ou dans la section

de sortie de chaleur (22; 122) au moyen d'un échangeur de chaleur (34; 134; 234; 334) qui couple la source de chaleur (38; 138; 238; 338) et le puits de chaleur (32; 132; 232; 332) avec le système de tuyauterie (10),

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**caractérisé en ce qu'un ventilateur (40; 140; 240; 340) attribué à l'échangeur de chaleur (34; 134; 234; 334) respectif est utilisé pour commander le transfert de chaleur entre l'échangeur de chaleur (34; 134; 234; 334) et la source de chaleur (38; 138; 238; 338),** dans lequel le flux du milieu de transport de chaleur (20) est commandé entre la section d'admission de chaleur (14; 114) et la section de sortie de chaleur (22; 122; 222; 322), et dans lequel un robinet de régulateur (156; 278; 280; 286; 378; 386) est attribué au système de refroidissement, au moyen duquel la quantité de milieu de transport de chaleur s'écoulant vers et/ou de l'échangeur de chaleur (34; 134; 234; 334) est commandé.

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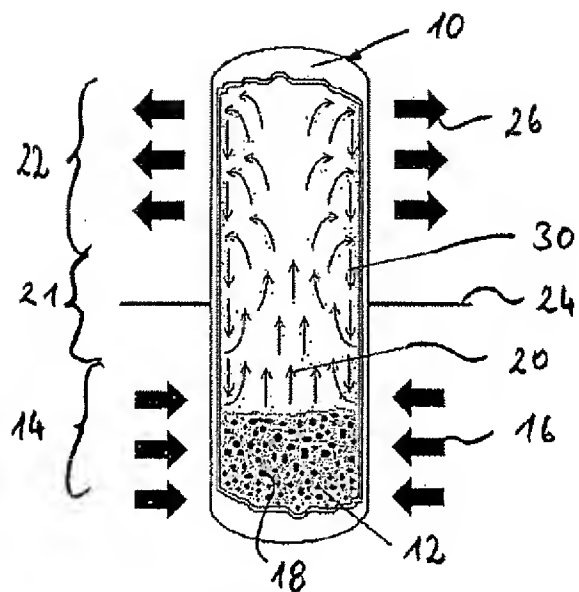


Fig. 1

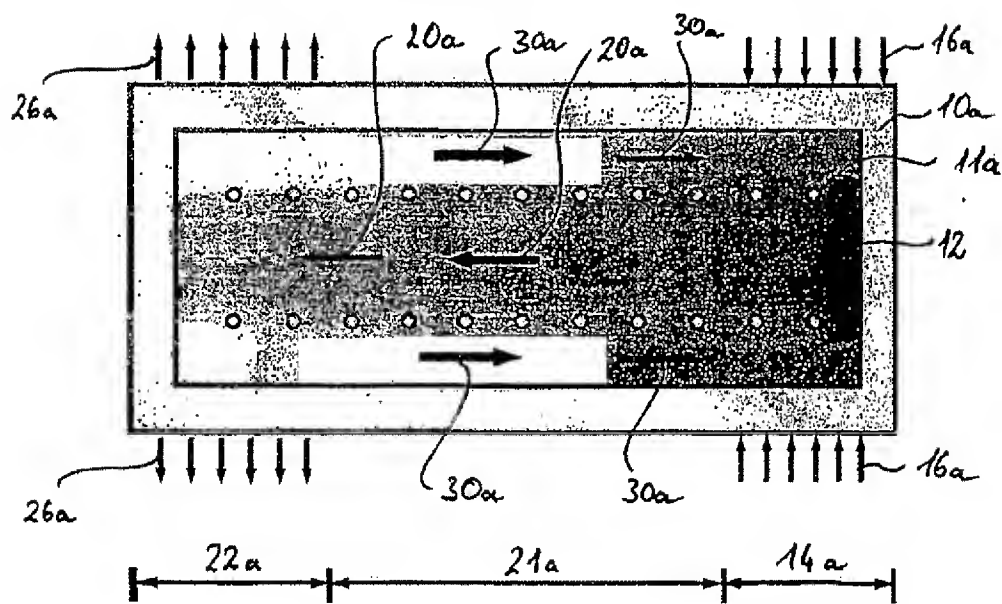
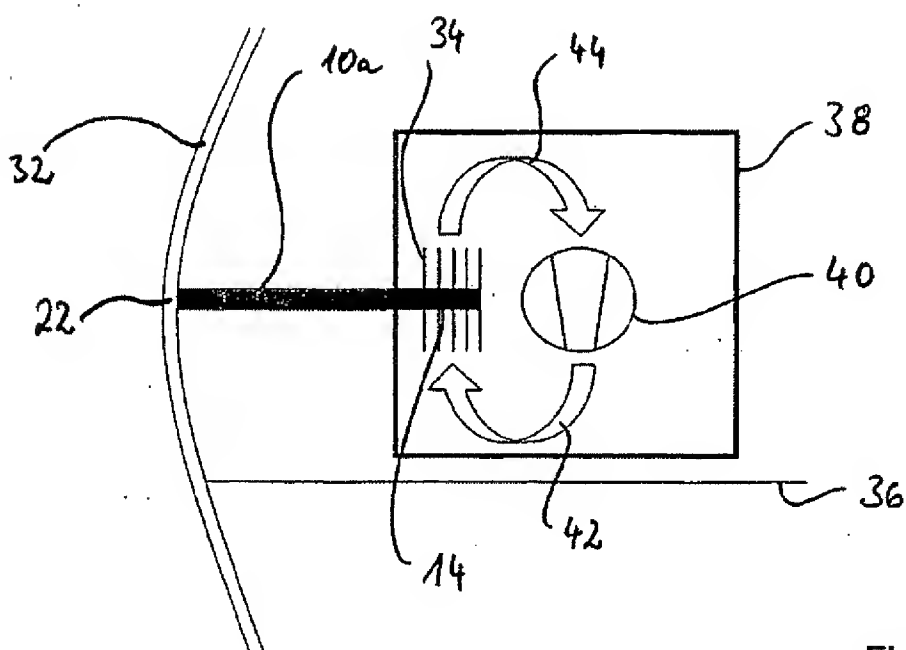
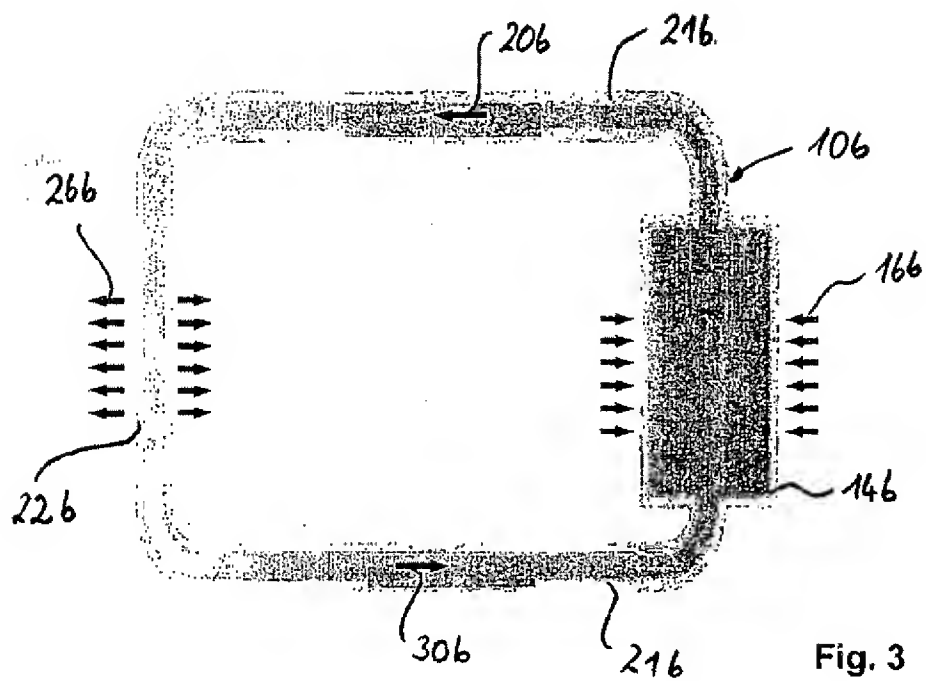


Fig. 2



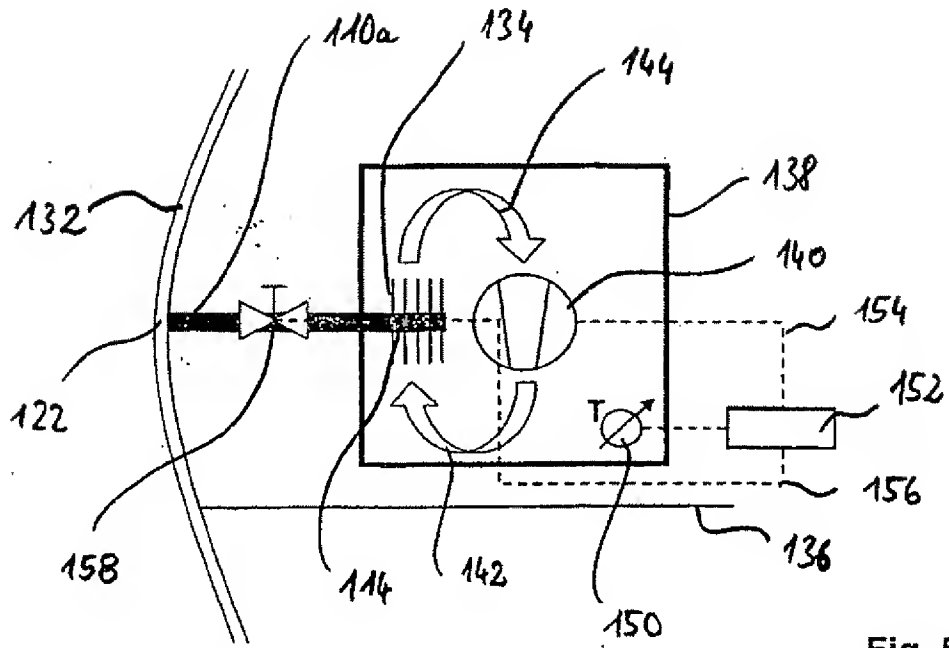


Fig. 5

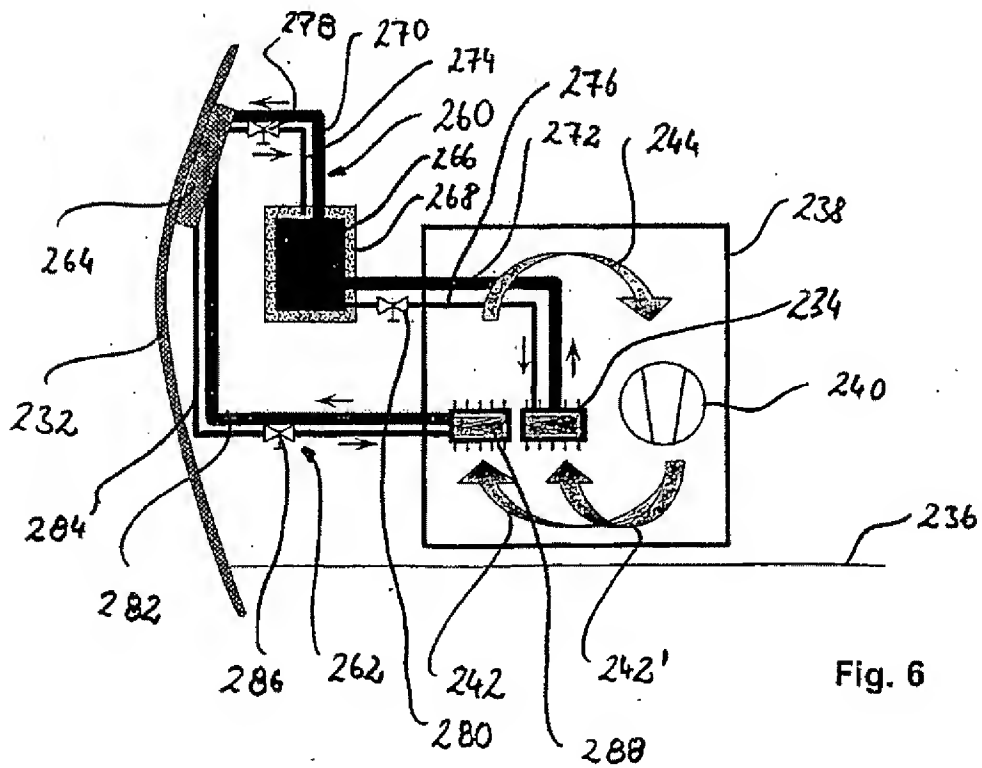
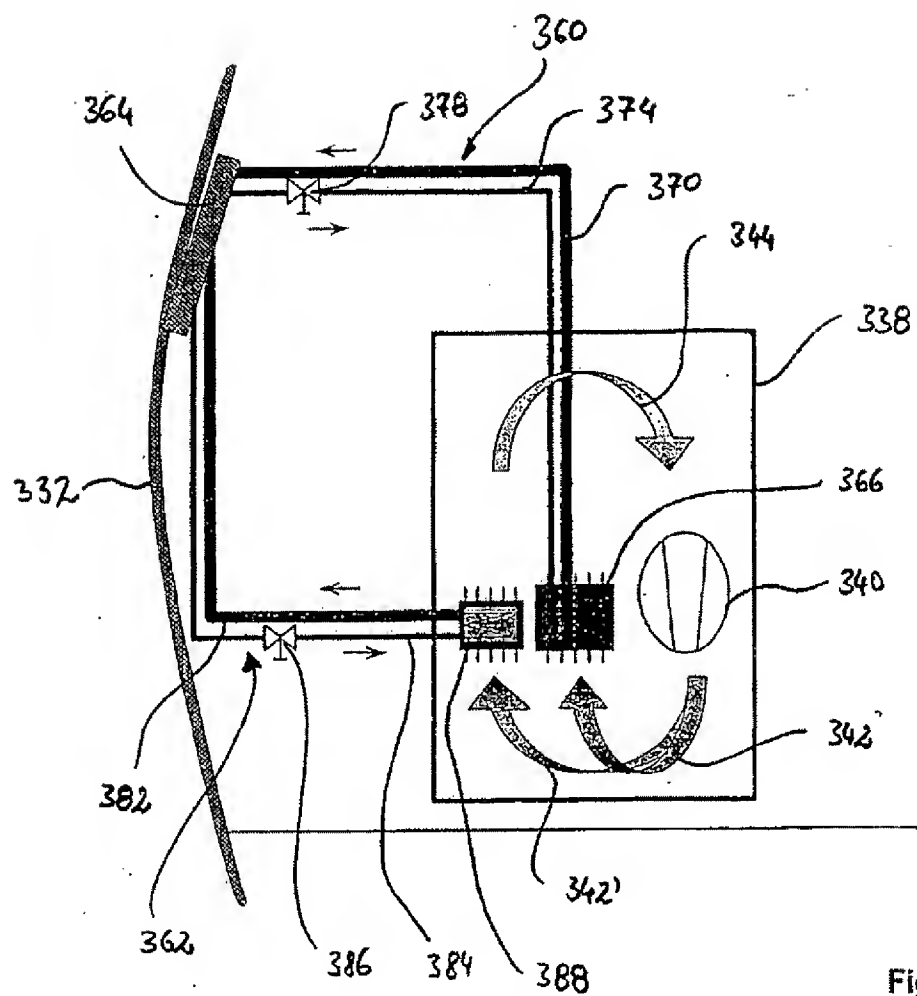


Fig. 6



**Fig. 7**

REFERENCES CITED IN THE DESCRIPTION

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